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MINI-FOCUS ISSUE: TRANSRADIAL APPROACH
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A Randomized Comparison of Transradial Versus Transfemoral Approach for Coronary Angiography and Angioplasty

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Objectives The aim of the study was to evaluate the safety, feasibility, and procedural variables by the transradial approach compared with the transfemoral access in a standard population of patients undergoing coronary catheterization.

Background Coronary catheterization is usually performed via the transfemoral approach. Transradial access may offer some advantages in comparison with transfemoral access especially under conditions of aggressive anticoagulation and antiplatelet treatment.

Methods Between July 2006 and January 2008, a total of 1,024 patients undergoing coronary catheterization were randomly assigned to the transradial or transfemoral approach. Patients with an abnormal Allen's test, history of coronary artery bypass surgery, simultaneous right heart catheterization, chronic renal insufficiency, or known difficulties with the radial or femoral access were excluded.

Results Successful catheterization was achieved in 494 of 512 patients (96.5%) in the transradial and in 511 of 512 patients (99.8%) in the transfemoral group ($p < 0.0001$). Median procedural duration (37.0 min, interquartile range [IQR] 19.6 to 49.1 min vs. 40.2 min, IQR 24.3 to 50.8 min; $p = 0.046$) and median dose area product (38.2 $Gycm^2$, IQR 20.4 to 48.5 $Gycm^2$ vs. 41.9 $Gycm^2$, IQR 22.6 to 52.2 $Gycm^2$; $p = 0.034$) were significantly lower in the transfemoral group compared with the transradial access group. A median amount of contrast agent was similar among both groups. Vascular access site complications were higher in the transfemoral group (3.71%) than in the transradial group (0.58%; $p = 0.0008$)

Conclusions The findings of the present study show that transradial coronary angiography and angioplasty are safe, feasible, and effective with similar results to those of the transfemoral approach. However, procedural duration and radiation exposure are higher using the transradial access. In contrast to the transfemoral route, the rate of major vascular complications was negligible using the transradial approach. (J Am Coll Cardiol Intv 2009;2:1047–54) © 2009 by the American College of Cardiology Foundation

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Coronary angiography and angioplasty are usually performed via the transfemoral approach. Transradial access for coronary artery catheterization offers some advantages in comparison with the transfemoral route. Especially under conditions of aggressive anticoagulation and antiplatelet treatment, vascular bleeding complications at the femoral puncture site can result in increased morbidity and duration of hospitalization (1). Therefore, the rationale for the transradial approach is the intention to reduce access site bleeding complications, earlier ambulation, and improved patient comfort (2–4).

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Despite these striking and proven advantages, the use of the transradial route for coronary angiography or angioplasty in routine practice is still low. One reason for this could be that many studies about transradial catheterization were performed in high-volume centers by expert operators, making their results not fully applicable to the real world. In order to assess the safety, feasibility, and efficacy of transradial catheterization, we prospectively investigated the caseload of 4 cardiologists working in a community hospital with moderate procedural volume.

Abbreviations and Acronyms

ACT = activated clotting time
CAD = coronary artery disease
DAP = dose area product
IQR = interquartile range
PCI = percutaneous coronary intervention
UFH = unfractionated heparin

Methods

Patient group. All patients referred for diagnostic or interventional cardiac catheterization were screened for participation. Eligible patients were randomly assigned by computer generation (in 2 blocks in a 1:1 ratio) to either transfemoral or transradial catheterization. History of coronary artery bypass surgery, cardiogenic shock, known difficulties with the femoral (i.e., Leriche syndrome, severe peripheral artery disease, large abdominal aortic aneurysm) or radial approach (i.e., Raynaud syndrome), simultaneous right heart catheterization, a pathologic Allen's test, necessity for a preprocedural implantation of a transient pacemaker, chronic renal insufficiency (creatinine >2.0 mg/dl) with the potential necessity of using the radial artery as a native fistula in the future, hemodialysis patients with an arteriovenous fistula, absence of an experienced operator, or patient refusal were considered as exclusion criteria. All patients gave written informed consent before cardiac catheterization procedures.

Allen's test. Allen's test was performed by simultaneously occluding the radial and ulnar arteries while the patient was making a fist. Afterwards, the patient opened the hand, and the ulnar artery was released. A delay of >15 s before the return of color to the blanched hand was considered an abnormal Allen's test (5).

Vascular access. Selection of the access site was individualized according to the preferences of the operator and appropriateness of radial or femoral artery pulsations. Crossover from one arterial site to another was permitted at any time after randomization at the physician's discretion. Radial sheaths for diagnostic and interventional procedures had a diameter of 5- and 6-F, respectively. For the transradial approach, 0.3 mg isosorbide dinitrate to prevent radial artery spasm and 5,000 IU of unfractionated heparin (UFH) to prevent thrombosis were injected directly into the radial artery through the sheath; 5-F sheaths were used for transfemoral diagnostic procedures. Transfemoral interventions were performed using 6-F sheaths in 85% of cases and 7-F in the remaining.

Vascular hemostasis. Arterial sheaths were removed immediately after diagnostic or interventional transradial procedures while still being anticoagulated. Hemostasis was obtained using a pressure bandage with 4 elastic sticky straps immediately applied to the puncture site without a period of manual compression. Patients were allowed to walk immediately but not to make use of the punctured arm for the following 4 h after the procedure. The bandage was removed after 6 h.

In case of transfemoral diagnostic catheterization, the sheaths were removed in the catheterization laboratory, and hemostasis was obtained by manual compression. A bandage was applied, and the patients were restricted to bed rest for 6 h. After an interventional procedure via the transfemoral approach, vascular closure devices (Angioseal, Minnetonka, Minnesota; StarClose SE, Redwood City, California) were used in 179 of the patients (93.2%). Hemostasis in the remainder where the application of a closure device was forbidden (severe atherosclerosis, small diameter of the femoral artery) was achieved by manual compression followed by a bandage for an additional period of 6 h when the activated clotting time (ACT) declined to <180 s.

Catheterization procedures. All 4 participating interventional cardiologists were required to have performed at least 50 transradial catheterizations before participation and to have extensive experience performing transfemoral procedures. Selective catheterization of the right and left coronary arteries was carried out followed by hand injection of the contrast agent. The vessels and lesions were analyzed using a computerized quantitative analysis system (Philips Medical System, Eindhoven, the Netherlands) according to previously described and validated edge-detection algorithms (2). Left ventricular ejection fraction was assessed from the angiogram and determined from 30° right anterior oblique projections. In case of percutaneous coronary intervention (PCI), angiographic success was assumed if a residual stenosis in the vessel diameter of <30% with

Thrombolysis In Myocardial Infarction (TIMI) flow grade 3 according to the classification of the TIMI trial could be achieved from the assigned access site (6).

Our institution's laboratory is equipped with 2 single-plane angiocardiographic systems (Allura Xper FD 10 C, Philips, Arnheim, the Netherlands). Dose rate options are available (high, normal, and low for fluoroscopy). All operators preferentially used the low system for fluoroscopy, which was exclusively performed in grid-pulsed operation. The units have digital cine with CD archiving. After calibration, the dose area product (DAP) was measured with an ionization chamber mounted directly at the output of the collimator. This device was a microprocessor-controlled measuring system featuring 2 independent channels. DAP measurements were expressed as $Gycm^2$.

Anticoagulant and antiplatelet regimen. After sheath insertion, all patients received a bolus of 5,000-IU UFH intra-arterially. At the end of the procedure, 5,000-IU protamine was administered in a protamine-to-heparin ratio of 1:1 without measurement of ACT before removal of the femoral sheath. In case of an intervention, an additional bolus of 5,000-IU UFH and 500 mg aspirin were given intravenously. Additional heparin was administered, if necessary, to maintain an ACT >300 s. The use of glycoprotein IIb/IIIa antagonists was left to the operator's discretion. All patients received 300-mg clopidogrel immediately after the intervention or the day before intervention followed by 75-mg clopidogrel and 100-mg aspirin once a day for a period of 4 weeks after bare-metal stent implantation or 12 months after drug-eluting stent implantation. Thereafter, all patients received aspirin 100 mg a day indefinitely.

Cardiovascular risk factors. Cardiovascular risk factors were defined as follows: history of smoking if patients had smoked within the last 10 years; hypertension, if blood pressure >140/90 mm Hg had been documented; hypercholesterolemia if total cholesterol and/or low-density lipoprotein cholesterol levels were higher than 200 mg/dl and 150 mg/dl, respectively; family history of coronary artery disease (CAD) if myocardial infarction or coronary artery intervention had occurred in a first-degree relative; diabetes was assumed if the patient took oral antidiabetic medication or insulin or fasting blood glucose was >100 mg/dl.

Study end points. We collected data about procedural success rate, causes for switch to alternative access, procedural duration, fluoroscopy time, DAP, and amount of contrast agent. Procedural time was taken as the time of entry of the patient into the catheterization laboratory to the end of the procedure. Time required for hemostasis was not included. Additionally, vascular access site complications during hospitalization, like pseudoaneurysm, arteriovenous fistula, retroperitoneal hematoma, limb ischemia, surgical vascular repair, loss of radial artery pulse and major bleedings, defined as a hemoglobin level decline of at least 3 g/dl or administration of blood transfusion, were recorded.

Statistical analysis. Clinical, angiographic and procedural data were prospectively entered into a computerized database. Absolute numbers and percentages are computed to describe the patient population. Continuous variables are expressed as mean ± SD and are compared using the unpaired *t* test for normally distributed and Mann-Whitney *U* test for non-normally distributed variables. Categorical variables are expressed as absolute or relative frequencies and are compared using chi-square analyses or the Fisher exact test, as appropriate to the cell frequencies. Fluoroscopy time, amount of contrast agent, DAP, and procedural duration, which were not normally distributed, are expressed as the median, together with the interquartile range (IQR). Values of $p < 0.05$ were considered statistically significant. SPSS 13.0 for Windows (SPSS Inc., Chicago, Illinois) was used for statistical analysis.

Results

From July 2006 to January 2008, a total of 2,316 patients were screened for participation. Of these, 1,024 patients (44.2%) with palpable femoral and radial pulses and a normal Allen's test undergoing coronary artery catheterization were randomly assigned to the transradial or transfemoral approach (Fig. 1). The causes for exclusion were an ischemic Allen's test (n = 347), absence of an experienced interventional cardiologist (n = 293), history of coronary artery bypass surgery (n = 279), chronic renal insufficiency (n = 176), known severe peripheral artery disease (n = 52), patient refusal to participate in the study (n = 49), simultaneous transient pacemaker implantation (n = 34), presence of an arteriovenous fistula (n = 32), known large abdominal aortic aneurysm (n = 29), and cardiogenic shock (n = 1).

Baseline features of the randomized patients are expressed in Table 1. The groups were well balanced regarding age, sex, and body mass index. There were no significant differences between both groups either in cardiovascular risk factors (smoking, hypertension, diabetes, hypercholesterolemia, family history of CAD), or in terms of previous myocardial infarction or previous PCI. Eighty-five patients were enrolled with acute ST-segment elevation myocardial infarction, 45 patients (8.8%) in the transradial group and 40 patients (7.8%) in the transfemoral group.

The angiographic data are shown in Table 2. From the 1,024 randomized patients, 42 (8.2%) in the transradial group and 37 (7.2%) in the transfemoral group had normal angiograms. The extent of CAD and left ventricular ejection fraction (46 ± 14% in the transradial group and 49 ± 16% in the transfemoral group; p = 0.70) were similar.

Procedural results are detailed in Table 3. Successful catheterization was achieved in 494 (96.5%) of 512 patients in the transradial group and in 511 patients (99.8%) of 512 patients in the transfemoral group ($p < 0.0001$). Only 1

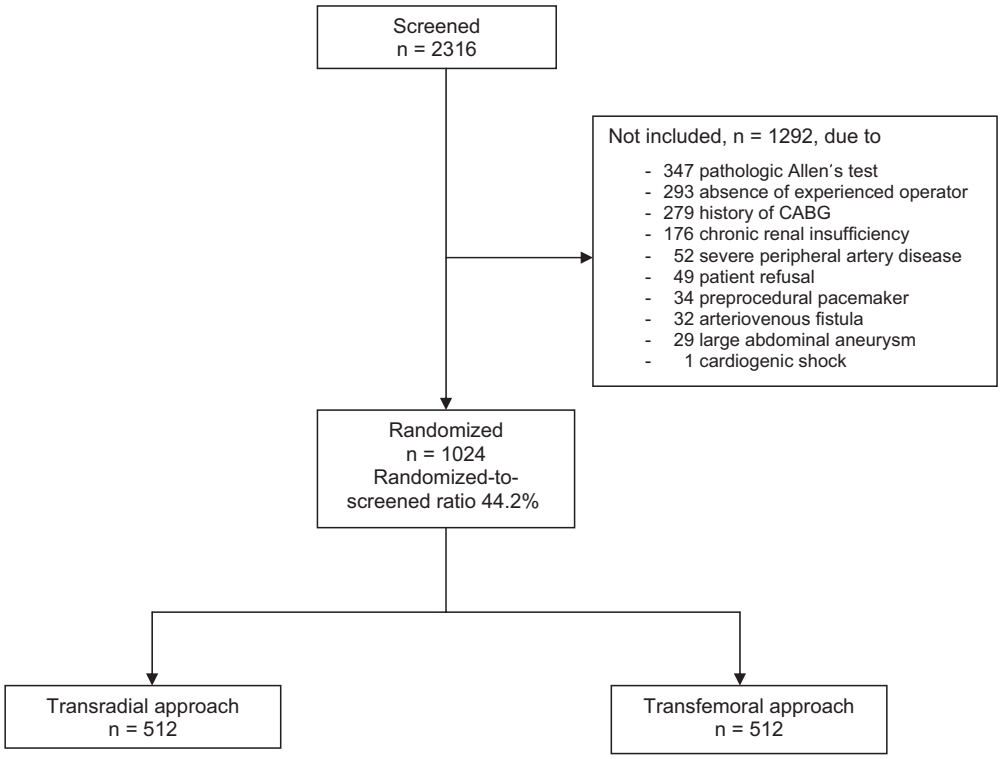

Figure 1. Disposition of Patients Throughout the Study

A total of 2,316 patients were initially screened. Of those, 1,024 patients met eligibility criteria and were randomly assigned to the transradial and transfemoral approach.

patient in the transfemoral group (0.2%) required crossover to the transradial access because of an angiographically proven occlusion of the abdominal aorta. The complete procedure was performed via the right radial approach without any problems. The 18 failed attempts in the transradial group (3.5%) were due to radial artery spasm (n = 6), tortuosity of the innominate trunk (n = 5), radial artery puncture failure (n = 3), dilation of the ascending

Table 1. Baseline Clinical Characteristics of the 1,024 Study Patients

	Radial Group (n = 512)	Femoral Group (n = 512)	p Value
Age, yrs	63.2 ± 11.9	64.1 ± 12.1	0.10
Male sex	292 (57.0)	309 (60.4)	0.31
Height, cm	170 ± 9	170 ± 9	0.79
Weight, kg	82.2 ± 17.9	82.4 ± 15.2	0.78
Body mass index, kg/m^2	28.4 ± 5.8	28.4 ± 4.3	0.49
Risk factors			
History of smoking	77 (15.0)	91 (17.8)	0.27
Hypercholesterolemia	235 (45.9)	228 (44.5)	0.71
Hypertension	323 (63.1)	343 (67.0)	0.21
Diabetes	132 (25.8)	127 (24.8)	0.77
Family history of CAD	82 (16.0)	76 (14.8)	0.67
Acute STEMI (<12 h)	45 (8.8)	40 (7.8)	0.65
Recent MI	104 (20.3)	122 (23.8)	0.20
Previous PCI	118 (23.0)	127 (24.8)	0.56

Data presented are mean ± SD or n (%).
CAD = coronary artery disease; MI = myocardial infarction; PCI = percutaneous coronary intervention; STEMI = ST-segment elevation myocardial infarction.

Table 2. Angiographic Data

	Radial Group (n = 512)	Femoral Group (n = 512)	p Value
CAD, n (%)	419 (81.8)	431 (84.2)	0.36
CAD stenosis <50%	57 (11.1)	60 (11.7)	0.84
CAD stenosis ≥50%	362 (70.1)	371 (72.5)	0.84
1-vessel disease	93	88	0.59
2-vessel disease	113	116	0.95
3-vessel disease	156	167	0.65
Heart valve disease	8 (1.6)	4 (0.8)	0.38
Cardiomyopathy	24 (4.7)	25 (4.9)	1.00
Hypertensive heart disease	18 (3.5)	14 (2.7)	0.59
Myocarditis	1 (0.2)	1 (0.2)	1.00
Normal	42 (8.2)	37 (7.2)	0.64
LV ejection fraction, %	46 ± 14	49 ± 16	0.70

Data presented are mean ± SD, n (%), or n.
CAD = coronary artery disease; LV = left ventricular.

Table 3. Procedural Data

	Transradial (n = 512)	Transfemoral (n = 512)	p Value
Total procedures	512	512	
Access failure	18 (3.5)	1 (0.2)	<0.0001
Diagnostic procedure	14	1	
Interventional procedure	4	0	
PCI	178 (34.8)	192 (37.5)	0.40
Ad-hoc PCI (% of PCI)	162 (91.0)	179 (93.2)	0.55
Drug-eluting stents	23.4	25.7	0.76
Procedural failure of PCI	6 (3.4)	1 (0.5)	0.06
Vascular closure device	—	179 (93.2)	
Median procedural time, min (IQR)	40.2 (24.3–50.8)	37.0 (19.6–49.1)	0.046
Median fluoroscopy time, min (IQR)	9.0 (3.9–10.7)	5.8 (1.7–7.5)	0.001
Median contrast amount, ml (IQR)	132 (80–160)	129 (90–160)	0.43
Median DAP, $Gycm^2$ (IQR)	41.9 (22.6–52.2)	38.2 (20.4–48.5)	0.034
Access-related complications	3 (0.58)	19 (3.71)	0.0008
Cerebrovascular accidents	0 (0)	2 (0.39)	0.50

Data are presented as n, n (%), or median (IQR).
DAP = dose area product; IQR = interquartile range; PCI = percutaneous coronary intervention.

aorta (n = 2), lusoria artery (n = 1) and inability to track the device in the left main (n = 1). In all cases, the procedure was successfully performed by the transfemoral approach.

The overwhelmingly large majority of PCIs were ad-hoc angioplasty (91.0% in the transradial group and 93.2% in the transfemoral group; p = 0.55). Overall success rate in PCI was 99.5% in the femoral group and 96.6% in the transradial group (p = 0.06). There was 1 stent delivery failure due to a tortuous coronary artery in the transfemoral group. Causes of interventional failure in the transradial group were severe radial artery spasm (n = 3), tortuosity of the innominate trunk (n = 2), and impossible engagement of the left main (n = 1) requiring switch to the transfemoral, which was performed successfully in all cases. The percentage of patients treated by drug-eluting stent implantation was similar in both groups (23.4% in the transradial group and 25.7% in the transfemoral group; p = 0.76).

Procedural and fluoroscopic time, amount of contrast volume, and DAP are also shown in Table 3. Transradial access (median 40.2 min, IQR 24.3 to 50.8 min) took 3.2 min longer than the transfemoral approach (median 37.0 min, IQR 19.6 to 49.1 min, p = 0.046). Median fluoroscopic time was significant longer (p = 0.001) in the transradial group (9.0 min, IQR 3.9 to 10.7 min) compared with the transfemoral group (5.8 min, IQR 1.7 to 7.5 min). Median amount of contrast agent was similar among both groups (132 ml, IQR 80 to 160 ml in the transradial group; 129 ml, IQR 90 to 160 ml in the transfemoral group; p = 0.43). Median DAP was significantly increased in the transradial group compared with the transfemoral access group (41.9 $Gycm^2$, IQR 22.6 to 52.2 $Gycm^2$ vs. 38.21 $Gycm^2$, IQR 20.4 to 48.5 $Gycm^2$; p = 0.034).

Despite the usage of vascular closure devices in 179 patients (93.2%) after transfemoral intervention, vascular access site complications were higher in the transfemoral group (3.71%) compared with the transradial group (0.58%; p = 0.0008). Pseudoaneurysms were seen in none of the patients after transradial and in 3 patients after transfemoral procedure. Among these 3 patients with pseudoaneurysm, 2 of them underwent PCI with standard doses of aspirin, heparin, clopidogrel, and glycoprotein IIb/IIIa blockers due to ST-segment elevation myocardial infarction. All of them were successfully treated by ultrasound-guided thrombin injection with complete occlusion of the pseudoaneurysm. No patient was sent to surgery due to procedural complications. In the transfemoral group, 3 patients presented a severe groin hematoma that required blood transfusion, 11 patients (4 after angiography and 7 after PCI) presented a decline of hemoglobin level of at least 3 g/dl without the necessity of blood transfusion, and 2 patients suffered from an arteriovenous fistula after diagnostic angiography that was treated conservatively. Only 3 patients (0.59%) in the transradial group had no beating radial artery pulse at discharge without any evidence of forearm ischemia. No cases of major vascular or bleeding complications occurred in the transradial group.

Two patients in the transfemoral group experienced periprocedural neurological deficit: 1 patient suffered from a transient ischemic attack that promptly resolved after diagnostic coronary angiography, whereas the other one, during a PCI procedure, had a stroke with left hemplegia that was managed conservatively. No deaths occurred, and 7 patients (0.68%) experienced reinfarction or repeat PCI during the

in-hospital follow-up, 3 patients in the transradial group and 4 patients in the transfemoral group.

Discussion

The study showed that transradial coronary catheterization is highly feasible, safe, and effective for both diagnostic and therapeutic procedures in a standard population with the drawback of a lower overall procedural success rate (96.5%) as compared with the transfemoral access (99.8%; $p < 0.0001$). In a large meta-analysis by Agostoni et al. (7), the overall rate of procedural failure was 7.2% in the transradial group compared with 2.4% in the transfemoral group (odds ratio: 3.30, 95% confidence interval: 1.63 to 6.71; $p < 0.001$). Louvard et al. (8) reported a rate of 10% in the first 50 cases, 3% to 4% after other 500 cases, whereas it stabilizes at less than 1% only after 1,000 procedures. Consistent with these data, the rate of transradial access failure in the current study was 3.5%. Due to technical progress of equipment and increasing expertise of the interventional cardiologists, a trend toward similar procedural success rates could be anticipated.

Access failure. In spite of intra-arterial administration of nitrates, spasm of the radial artery was responsible (33%) for procedural failure in 6 cases in our study. Its occurrence seemed to be directly related to the duration of the procedure because 3 of 6 access failures in the transradial group owing to radial artery spasm were seen in procedures lasting longer than 60 min. Five access failures in the transradial group were due to tortuosity of the innominate trunk making an engagement of the coronary arteries impossible. Interestingly, a native calcification in the innominate trunk was visible in 4 of these 5 access failures requiring a switch to the transfemoral access route. Therefore, it is worthwhile to perform an X-ray of this area before transradial procedure in order to select these patients as being poor candidates for the transradial route. Female sex seemed to be a predictor for access failure because 13 of 18 patients (72%) with procedural failure were women.

Procedural duration. Transradial access is technically more demanding and time-consuming, especially in the early learning curve. In the current study, the procedural time in the transradial group (40.2 min) took a little bit longer than the transfemoral approach (37.0 min), but the difference was significant ($p = 0.048$). However, under most circumstances, it is unlikely that this time period would be clinically significant. Additionally, this time difference of 3.2 min did not include the time interval required for hemostasis, which may exceed 15 min after transfemoral catheterization. The time required to obtain hemostasis using transradial route is markedly shorter because manual compression is not necessary and the bandage could be applied immediately after the procedure. Therefore, procedural time does not constitute a strong rationale for the transfemoral approach, especially for experienced operators.

Radiation exposure. In accordance with other reports (9–13), the fluoroscopic time in the current study was significantly longer in the transradial group compared with the transfemoral procedure. This prolonged fluoroscopic time was associated with an increased radiation exposure of the patient. We did not measure the DAP of the operator, but Brasselet et al. (12) reported that the radiation exposure of the operator in a transradial approach was increased as well, despite using optimized specific protection devices, reflecting technical difficulties and a slightly closer position of the interventional cardiologist to the X-ray source. This increased radiation exposure is currently a growing problem for the health of the interventional cardiologist casting a shadow of caution on the transradial access.

Entry site complications. Access site complications are considerably more frequent whenever an aggressive antiplatelet and/or antithrombotic treatment is needed. Consequently, transfemoral intervention in acute myocardial infarction carries a risk of bleeding complications ranging from 2.5% to 23% (10,14–16). Obesity, elderly patients, and female sex have also been linked to an increased occurrence of access site complications (17). In our study, the occurrence of groin complications after transfemoral catheterization could be limited to 3.71%. Like other authors (2,4,18,19), we could confirm the low rate of entry site complications using the transradial approach, as indeed only 3 local complications (0.58%) were found in 512 patients. The radial artery is easily compressible due to its superficial course, achieving adequate hemostasis only with a bandage. To our knowledge, this is the first randomized trial comparing access site complications after coronary procedures via transradial versus transfemoral access with a closure device. Even with the technologic improvement of these devices and increasing experience regarding their use, we demonstrated a clear benefit of the transradial approach as to the occurrence of peripheral arterial complications.

In the current study, the randomized-to-screened ratio of patients enrolled was 44.2%, and the main reason for failed eligibility was a pathologic Allen's test excluding 347 of 2,316 screened patients (14.9%). The incidence of an abnormal Allen's test in patients undergoing coronary angiography ranges from 6.4% to 27% (20,21). But the visual assessment of the Allen's test has a limited specificity because of delayed recruitment of collateral flow. Studies using Doppler ultrasound, plethysmography, and pulse oximetry revealed a sufficient supply by the ulnar artery in most patients with a pathologic Allen's test (20,22). However, an elevated thumb capillary lactate level was measured in these patients (23). From our point of view, transradial catheterization should be avoided in the presence of an abnormal Allen's test unless the risk of using the transfemoral approach is exceedingly increased (e.g., severe peripheral

vascular disease, morbid obesity, large abdominal aortic aneurysm, Leriche syndrome).

At discharge, we found no pulse in the cannulated radial artery in 3 patients (0.58%) without clinical signs of forearm ischemia. In other trials, loss of radial pulse was present in 0% to 9% (4,24) without clinical sequelae. Using ultrasound assessment, the post-procedural absence of a radial flow was detected in 9% (1,25), subsequently decreasing to 3% to 6% in follow-up (4,24,26–28). The occurrence of radial occlusion is a rare event, particularly if the vessel is not overstretched (sheath size ≤6-F), intra-arterial heparin is administered without neutralization by protamine at the end of the cannulation, the arterial sheath is withdrawn immediately after the procedure, and the bandage is removed as soon as hemostasis is achieved. Radial artery occlusion after the transradial approach is directly related to the ratio between the sheath and artery size (29). Therefore, smaller guiding catheters are potentially advantageous leading to less arterial spasm, pain, and post-procedural vessel occlusion. However, the authors and their colleagues have shown that, during PCI, 5-F catheters offer no advantages concerning radial artery occlusion as compared with 6-F catheters, with the drawback of a 7% crossover rate from 5- to 6-F (30).

Although there were no redo angiographies through the same radial artery in the transradial group, it could be demonstrated by Kamiya et al. (31) and Yoo et al. (32) that after transradial catheterization the radial artery could be used for both coronary artery bypass surgery as an arterial graft and repeat catheterization.

Cerebral embolism. Lund et al. (33) raised concerns that transradial access may induce subclinical solid cerebral microemboli at a higher extent than the transfemoral approach. As assessed by magnetic resonance imaging, 15% of patients suffered embolization toward the brain when the catheter passed from the right arm to the aorta in those examined with transradial access compared with none in the transfemoral group (33). We could not confirm these data in our study. Both patients suffering from cerebral embolism were investigated through the femoral artery making a detachment of larger atherosclerotic plaques from the aortic arch most likely. To prevent cerebral embolism, we strongly recommend cautious manipulation and gentle advancement of guidewires and catheters especially in the aortic arch and the aortic-subclavian conjunction, and exchange of catheters over the guidewires while leaving them in the ascending aorta.

Study limitations. We recognize that the present study has several limitations. First, we did not assess other important parameters such as patient comfort, hospital stay, and the incidence of smaller hematomas not requiring blood transfusion. Second, no systematic ultrasound examination of post-procedural radial artery patency was performed; consequently, the percentage of radial occlusion, even when a radial pulse was present, may have been underestimated. Third, as already mentioned, we did not measure the radiation exposure of the operator. Moreover, we have to emphasize that the data apply to a selected population because only 44% of the initially screened patients could be randomized. Finally, we used 5,000-IU heparin intravenously for diagnostic procedures and an additional bolus of 5,000-IU heparin for interventional procedures as anticoagulants. Using a weight-adapted regimen with 60-IU heparin/kg or low-molecular-weight heparin (i.e., enoxaparin), the frequency of access-related bleeding complications, especially in the transfemoral group, could have been reduced.

Conclusions

Transradial coronary catheterization is safe, feasible, and effective. However, transradial access is limited by a significantly higher rate of procedural failure. In addition, procedural duration (excluding hemostasis period), fluoroscopy time, and radiation exposure are higher compared with transfemoral access. Furthermore, it does not allow the possibility of using other devices such as a temporary pacemaker or intra-aortic balloon pump or to perform PCI requiring 8-F catheters. However, the radial approach nearly abolishes entry site complications, in comparison with significantly higher rates in patients undergoing transfemoral catheterization. Both vascular access techniques should not be considered opposite or mutually exclusive, but rather provide the interventionalist with a wider spectrum of therapeutic options.

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Key Words: access site complications ■ coronary angiography ■ transfemoral approach ■ transradial approach.